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# BIG SANDY RIVER BASIN. REPORT ON LOW FLOW REGULATION AND NAVIGATION POOL EVALUATION - POLLUTION ABATEMENT AND WATER SUPPLY

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

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# BIG SANDY RIVER BASIN

## Report on Low Flow Regulation and Navigation Pool Evaluation - Pollution Abatement and Water Supply -

Prepared by

U. S. Department of
Health, Education, and Welfare
Public Health Service

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

Prepared at the request of and in cooperation with the District Engineer Huntington District, Corps of Engineers

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Report on Low Flow Regulation
and Navigation Pool Evaluation -
Pollution Abatement and Water Supply -
Big Sandy River Basin

In accordance with a request dated August 2, 1956 from the office of the District Engineer, Huntington District, Corps of Engineers, U. S. Army, this report has been prepared covering requested information as to the value of certain increases in low flow from the standpoint of pollution abatement and water supply, and the value or damage to water supplies by development of a series of navigation pools.

The reaches for which evaluations were requested are set out below:

| Stream | Reach | Low Flow Increase (c.f.s.) |
|---|---|---|
| Big Sandy River | Mouth of Blaine Creek to Mouth of Big Sandy River | 50,100,200 300,500 |
| Big Sandy River | Louisa, Ky. to Blaine Creek | 50,100,200,300 |
| Levisa Fork | Mouth of Paint Creek to Louisa, Ky. | 50,100,200,300 |
| Russell & Levisa Forks | Virginia-Kentucky Line to Paint Creek | 200 |
| Tug Fork | Mouth Big Creek (Nolan, W. Va.) to Louisa, Ky. | 50 |
| Ohio River | Below Mouth of Big Sandy River | 50,100,200,300 and 500 |

These flow increases were considered both with and without navigation pools. Head of navigation on Levisa Fork would be at the confluence of Russell and Levisa Forks, while head of navigation on Tug Fork would be approximately at Merrimac, W. Va.

Conclusions have been drawn from the analysis of data collected during the Ohio River Pollution Survey (1939) (HR-266,78-1), from the Zoning Report of the Big Sandy River Basin dated August 1, 1949 by the West Virginia Water

Commission, and from more recent data furnished by the Kentucky Water Pollution Control Commission and by the West Virginia Water Commission. Reference is made also to two previous reports by the Public Health Service; (1) Memorandum Report covering low-water-flow regulation for pollution abatement-Big Sandy Basin, dated November 5, 1940 and (2) a letter report dated April 20, 1945 and modified November [illegible], 1945, made to ascertain possible effects to water supply and stream pollution abatement resulting from proposed navigation developments on the Big Sandy River and its two principal tributaries, Tug Fork and Levisa Fork.

As present pollution conditions in the Big Sandy River Basin are believed similar to those determined in 1939 the general conclusions previously reported are still valid. However, where conditions have changed significantly since 1945, benefits have been reevaluated. All conclusions pertinent to benefits or damages are shown in the below listed statements:

Conclusions

1. There are no tangible pollution abatement benefits attributable to low flow regulation in the Big Sandy River for the projects considered.
2. The pollution abatement benefits to the Cincinnati-Covington area are no longer $10,000 per 100 c.f.s. as previously reported, due to changed conditions in the Cincinnati-Covington area. The value of these benefits is insignificant at this time.
3. Canalization of the Big Sandy River will adversely affect the assimilative capacity of the Big Sandy River and Levisa Fork and Tug Fork. However, if primary treatment plants (chlorination in-

cluded) were in operation in the larger municipalities, there would be no significant pollution problem. Therefore canalization would not be considered a damage in this respect.

4. There will be intangible benefits to pollution abatement due to low flow regulation as increased flows will have a distinctly beneficial effect, tending to increase water quality above the minimum objectives, both in the Big Sandy River Basin and in the Ohio River.

5. There are no apparent industrial water supply benefits attributable to low flow regulation.

6. Canalization of the Big Sandy River, Tug Fork, and Levisa Fork, without low-flow augmentation, will cause a damage to water supply. The detrimental effect on water supplies would be due to the discharge of sewage into the same navigation pool as that used for a water supply intake. This damage can be measured by the cost of relocating the water supply intakes of the following municipalities not more than one mile upstream from present locations.

| Municipality | Population Served | Consumption M.G.D. |
|---|---|---|
| Fort Gay, W. Va. | 600 | .037 |
| Kermit, W. Va. | 3,500 | .165 |
| Williamson, W. Va. | 10,000 | 1.000 |
| Louisa, Ky. | 2,050 | .067 |
| Paintsville, Ky. | 4,450 | .312 |
| Van Lear, Ky. | 1,140 | .070 |
| Prestonburg, Ky. | 3,630 | .203 |
| Allen, Ky. | 560 | .060 |
| Pikeville, Ky. | 5,450 | .327 |
| Shelbiana, Ky. | 150 | .010 |

7. Canalization of the Big Sandy River, Tug Fork, and Levisa Fork with a low flow augmentation of 50 c.f.s. minimum in the reach of any water supply, will not cause a damage to that water supply.
8. There are no benefits to water supply due to low flow augmentation.

## Pollution Abatement Considerations

A. Present Conditions

A detailed discussion of the stream sanitation problems of the Big Sandy Basin was previously presented in the Ohio River Pollution Survey Report (Vol. II. pp. 439-467). The pollution conditions of Levisa Fork in 1956, on the basis of population studies and information from the Kentucky Water Pollution Control Commission, are believed to be similar to those observed in 1939. Tug Fork-Big Sandy River pollution conditions were studied in 1947-48 and reported in 1949 by the West Virginia Water Commission. It is believed that the observed conditions of 1947-48 exist in 1956. The 1947-48 conditions were similar to those observed in 1939. An excerpt from the West Virginia Water Commission's Zoning Report dated August 1, 1948 is shown below:

"General Pollution Conditions

Big Sandy: It is apparent from Map V and Graph 17 that the Big Sandy is in Class B for the entire 27 miles from the confluence of Tug and Levisa Forks to the mouth. Graph 17 shows the stream to be Class B as a result of uniformly high coliform content throughout its length. Since these organisms originate in domestic sewage, the use of this stream for recreational purposes and as a source of public water supply has been impaired.

Tug Fork: Map V and Graph 17 show that three-fourths of the entire length of this stream is in Class C and that this zone of critical pollution extends

from the source to well below the city of Williamson. Graph 17 indicates that except for a short section above Matewan, high concentrations of coliform organisms, suspended fine coal particles, and resultant water color and coal sludges in the stream bed are responsible for the very poor stream conditions of this part of the watershed. Elkhorn Creek and its North Fork are the most critically polluted streams in the basin, and Map V shows this to be true as a result of the stream carrying large quantities of sewage and coal washery wastes. The very poor condition of Tug Fork in and below Welch is, to a great extent, caused by Elkhorn Creek. The extent of pollution from coal washery wastes is best described by stating that Tug Fork River, and all of its tributary streams of significance within McDowell County, are black almost the year around. The upper three-fourths of the stream is unsatisfactory as a source of water supply and its recreational value has been destroyed. Table V confirms this latter fact and points out that pollution has seriously reduced fishing in the entire West Virginia portion of the watershed. The Tug Fork and Big Sandy Rivers constitute the boundary between West Virginia and Kentucky, but in attempting to regulate pollution in the West Virginia portion of the stream, the Commission has considered it necessary to zone these streams."

B. Statement of Certain Principles of Pollution Abatement Evaluation.

In general, where wastes are discharged into flowing streams, the seriousness and the extent of the damage caused by the resulting pollution depends upon the volume of stream flow as related to the amounts and strength of the wastes discharged. A variety of other factors is involved, so that it is not practicable to establish standard dilution ratios which would be

generally applicable. Nevertheless, the dilution available is one of the most important factors governing the extent and seriousness of pollution. Therefore, pollution damage can be decreased either by reducing the waste load or by increasing the volume of dilution water. As most streams have widely varying natural flows, and as the design of waste treatment works must be based upon critical low-flow conditions, it is frequently possible to reduce the degree of treatment required by storing flood waters for release during low-flow periods.

Several important qualifications to these statements must be made. For many types of wastes, dilution alone can not be considered an entirely satisfactory substitute for treatment, at least within the range of dilutions which it might be practicable to provide. For example, oils and floating solids will be objectionable in many cases regardless of dilution water available. Settleable solids, either putrescible or inert (coal washeries wastes for instance) will not be greatly affected by added dilution. Sludge deposits from sewage or other organic wastes may exert an effect on the stream that is disproportionate to the pollution load in solution and in suspension in the stream.

Neither is dilution usually a suitable solution for problems of bacterial pollution. In such cases, the effects of dilution may be offset by the reduced time of flow from the source of pollution to the point of water use with fewer organisms dying in the shorter time period. For such pollution problems, waste treatment is essential to solution of the problem, and although additional dilution may be a valuable supplement to treatment, it can not be considered a satisfactory substitute.

Based upon the above reasoning, primary treatment of municipal wastes followed by disinfection of the effluent is believed to be necessary before any benefits can be credited to dilution flows as equivalent treatment plant costs. Conversely, similar treatment is presupposed before damages can be assessed due to canalization.

Where minimum natural flow is sufficient for dilution of the primary sewage treatment plant effluent, permitting a satisfactory minimum dissolved oxygen content at the critical point of the stream downstream from treatment plant outfall, no benefits can be credited to additional dilution water. However, where natural flows do not amount to the minimum required flows for dilution of plant effluent and maintenance of a minimum dissolved oxygen content at the critical point, supplementary dilution flows will have a value. Flow regulation in such cases will effect a savings in waste treatment cost insofar as it makes possible the elimination or reduction in the degree of more complete treatment than the above described minimum.

C. Effect of low flow regulation on design of future sewage treatment plants.

Low flow frequency curves for the rivers near municipalities were developed from flow data listed in the U.S.G.S. water supply papers.

For design purposes the municipalities considered were assumed to have a population ten per cent greater than that indicated in the 1950 census. In addition, it was assumed that these populations would be 100 per cent sewered.

It was assumed that the minimum dissolved oxygen content at 20°C should

be 5 ppm. The deoxygenation rate was estimated to be .16. The ratio of deoxygenation to reaeration for natural streams was estimated to be 2.0, while that ratio for impounded streams was estimated to be 1.4.

Using the above conditions, and the low flow, minimum monthly, with a frequency of 1 in 10 years, the sewage treatment plant requirements were estimated for the six largest municipalities affected by proposed projects. Elkhorn, Ky., on Russell Fork, Pikeville, Ky., Prestonburg, Ky., and Paintsville, Ky., all on Levisa Fork, Williamson, W. Va., on Tug Fork, and Louisa, Ky., on the Big Sandy were considered. As Catlettsburg, Ky., discharges sewage to the Ohio River, that municipality was not considered.

It was determined that under the conditions given above, there would be no benefits to pollution abatement due to low flow regulation as sufficient dilution water would be available for effluents from proposed primary sewage treatment plants. This was true for both natural and impounded rivers, except at Pikeville, Ky. (L/D 5 Impoundment).

At Pikeville, Ky., it was estimated that the impoundment without additional flow would be a damage to the river on the basis of lowered dissolved oxygen content. However, a total flow of 17 c.f.s. at Pikeville would remedy this damage. If a flow of less than 17 c.f.s. in the impounded river would be provided, then the damage to the river would be measured by the cost difference at Pikeville between a secondary sewage treatment plant (85% BOD removal) capital cost plus operation cost reduced to an annual charge and similar costs of a primary treatment plant.

While it is concluded that there are no tangible low flow regulation

benefits attributed to pollution abatement, increased flows will have a distinctly beneficial effect, tending to increase water quality above minimum objectives both in the reaches in the Big Sandy Basin affected by proposed projects and in the Ohio River.

Reference is made to a previous report of the Public Health Service dated November 5, 1940, wherein it is stated that the value of 100 c.f.s. low flow regulation in the Cincinnati-Covington area would be $10,000. That figure is no longer valid as Cincinnati is now providing additional sewage treatment facilities, the cost of which had been considered in estimating benefits of potential increased dilution waters. The benefits to Cincinnati would now be computed on the basis of savings of cost of chemicals not used when dilution waters are made available. The value of such benefits is insignificant at this time.

Public Water Supply

A. Effect of Low Flow Augmentation on Municipal Water Supplies.

Stream flows in the Big Sandy Basin are extremely variable. During periods of low-flow, cost of treating water may be somewhat greater than with larger flows due to increased use of chemicals. A study was made of the water supply problem of the below listed municipalities, assuming low flow augmentation as indicated:

| Municipality | Minimum Flow, c.f.s. |
|---|---|
| Catlettsburg, Ky. | 50,100,200,300,500 |
| Louisa, Ky. | 50,100,200,300 |
| Paintsville, Ky. | 200 |
| Van Lear, Ky. | 200 |

| Municipality | Minimum Flow, c.f.s. |
|---|---|
| Prestonburg, Ky. | 200 |
| Allen, Ky. | 200 |
| Pikeville, Ky. | 200 |
| Shelbianna, Ky. | 200 |
| Elkhorn City, Ky. | 200 |
| Kermit, W. Va. | 50 |
| Fort Gay, W. Va. | 50 |

It was concluded that for the type water plants considered, the cost difference between treatment during the minimum flow expected once in ten years and the augmented flow shown would be minor. No benefits could be developed for this water use due to increased flows.

B. Effect of Canalization on Municipal Water Supply
(Without low flow augmentation from Multipurpose Dams)

The probable effects of canalization as proposed on Tug Fork, Levisa Fork, and the Big Sandy River were described previously in a report dated November 8, 1945. There is no apparent reason to change the conclusions reached in that report. The probable damage is summarized in Conclusion 6. There may be a detrimental effect on water supplies due to discharge of sewage into the same navigation pool as that used for a water supply intake, and where different pools are used for sewage discharge and water supply intake, the pumping of lockage water may result in placing polluted water from a lower into a possibly less polluted upper water intake pool.

A study of proposed lock and dam locations with relation to existing water supply intakes at Williamson, W. Va., at Kermit, W. Va., and at

Paintsville, Ky., indicates a possible advantage to these municipalities by relocating their water intakes into an upstream pool. The relative locations are indicated below:

| Municipality | Location of Water Supply Intake (Mile Index) | Name and Location of Nearest L/d Upstream (Mile Index) | Distance (Miles) |
|---|---|---|---|
| Kermit, W. Va. | 35.20 | L/D 7 36.56 | 1.36 |
| Williamson, W. Va. | 57.50 | L/D 9 60.38 | 2.88 |
| Paintsville, Ky. | 38.70 | L/D 3 43.53 | 4.83 |

The principal advantage would be a large volume of a better quality water than that naturally available to each municipality. As shown on the above chart, all relocations would involve lengths greater than one mile, and therefore would probably require local financial participation. However, whether such relocations are desirable should be first considered by local water interests, and State Health Departments.

It should be pointed out that when construction of Greenup lock and dam is completed, the water supply of Catlettsburg, Ky. will be in an Ohio River pool. Canalization of the Big Sandy River will not adversely affect that municipality's water supply.

An objectionable taste and odor problem has developed in the drinking water of Catlettsburg, Ky. This situation was stated in the Public Health Report on the Big Sandy Basin to the Huntington District Engineer dated April 20, 1945. From frequent observations over the past ten years, it has been noted that the problem is sporadic and unpredictable as it has occurred under conditions of high dilution and has been absent at times of low flow.

The whole problem is complex and probably due to mixed natural and industrial pollution.

Generally, it is true that a good quality dilution water would improve a polluted raw water supply. However, in this particular case, it has been observed that high dilutions do not necessarily improve the taste and odor of finished drinking water.

Upon completion of Greenup Lock and Dam, the Catlettsburg water intake will be in an Ohio River pool. This impoundment will provide a navigable pool for about twelve miles up the Big Sandy River, and will have a water level three feet deeper at pool elevation than the present pool.

Based upon the observations stated above, and the new pool conditions, it is concluded that low flow augmentation of the magnitudes considered would not be a benefit to the water supply for this particular problem at Catlettsburg. Benefits to Catlettsburg water supply credited previously to low flow increases and listed in the April 20, 1945 report should be deleted for the above reasons.

## Industrial Water Supply

Over 55 M.G.D. from streams are used by industry in the Kentucky portion of the basin alone. The bulk of this water is used for cooling with the remainder used as boiler water and for washing coal. A large Kentucky industry which now has a water supply from the Big Sandy River, will have its intake in an Ohio River Pool upon completion of Greenup lock and dam. Canalization of the Big Sandy River should not adversely affect this industry.

About 40 coal washeries in Virginia and West Virginia, and 17 watering points for railroads in West Virginia use large quantities of water from streams.

As there is little other industrial development in the basin, there are no tangible benefits available due to low flow regulation.

It should be pointed out that the lack of industrial water supplies of sufficient quantity and good quality is a significant factor holding back the industrial development of the Big Sandy Basin. Raw materials such as coal and wood are readily available. Labor is abundant.

Rainfall is plentiful in the basin but water is not always available at the location desired at the cheap cost expected. Conservation of these waters is a most important need. The most productive activity in conserving surface waters would be the establishment of storage reservoirs at strategic locations on the tributaries to the main rivers. The reservoirs would impound surplus run-off and release stored waters during dry periods. An adequate system of reservoirs can add immeasurably to the economic growth of the Big Sandy Basin by providing large additional supplies of water for industrial use.